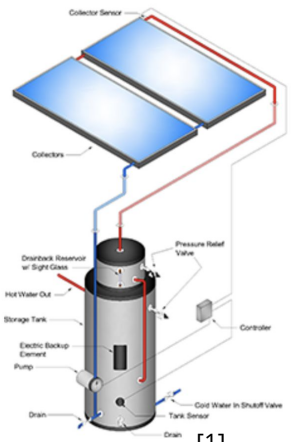


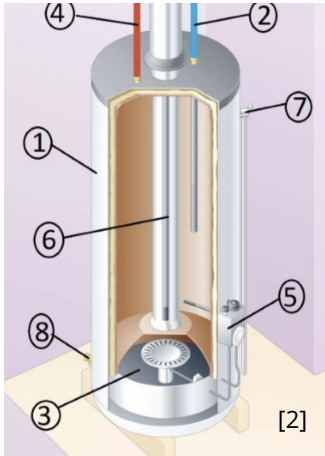
[1]

Team 12

MIE 315 Final Presentation

Why Solar is Better

Solar Thermal Water Heating vs Natural Gas Water Heating



[2]

Introduction and Background

Who is the Client?

- Uoft Cooperative Residences
- Owns 24 homes in Downtown Toronto

[3]


[4]

Introduction and Background

Who is the Client?

- Uoft Cooperative Residences
- Owns 24 homes in Downtown Toronto

What happened to them?

- Received grant to upgrade their water heating systems

[3]


[4]

Introduction and Background

Who is the Client?

- Uoft Cooperative Residences
- Owns 24 homes in Downtown Toronto

[3]

What happened to them?

- Received grant to upgrade their water heating systems

Why is this important?

- Water heating is essential in freezing climates
- Vital in ensuring health and safety of residents


[4]

Motivation for this Report

The Motivation

- Client is considering two systems
  - **Natural Gas Water Heating (NG)**
  - **Solar Thermal Water Heating (ST)**

[5]

The Goal

Increase Sustainability of Residences and Maximize grant through analysis of NG and ST systems

Motivation for this Report

The Motivation

- Client is considering two systems
  - **Natural Gas Water Heating (NG)**
  - **Solar Thermal Water Heating (ST)**

- Team is to determine which system is:
  - More sustainable
  - Maximizes the benefits of the grant

- Team will conduct various analyses that compare environmental impacts, costs, and overall function of systems

[5]

The Goal

Increase Sustainability of Residences and Maximize grant through analysis of NG and ST systems

Scope and System Boundary

The Scope

- Focus placed on five life cycle stages
  - Premanufacturing
  - Manufacturing
  - Distribution
  - Use
  - Disposal (In Certain Analyses)

- Focus only on impacts due to inputs, outputs and direct energy consumption of these life stages

[6]

[7]

Scope and System Boundary

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  - Use
  - Disposal (In Certain Analyses)

- Focus only on impacts due to inputs, outputs and direct energy consumption of these life stages

[6]

[7]

The System Boundary

- Common external features are excluded

- Processes related to by-products are excluded

- All emissions are included

Preliminary Consultant's Report


[9]

- *FOC's* - Functions, Objectives, & Constraints
- *SLCA* - Streamlined Life Cycle Assessment

Preliminary Consultant's Report


[9]

FOC's **- Functions, Objectives, & Constraints**

SLCA - Streamlined Life Cycle Assessment

Preliminary Consultant's Report


[9]

FOC's **- Functions, Objectives, & Constraints**

SLCA - Streamlined Life Cycle Assessment

Functional Unit: The amount of energy input required over 20 years to heat 160 gallons of water per day to 60 ℃

Functions

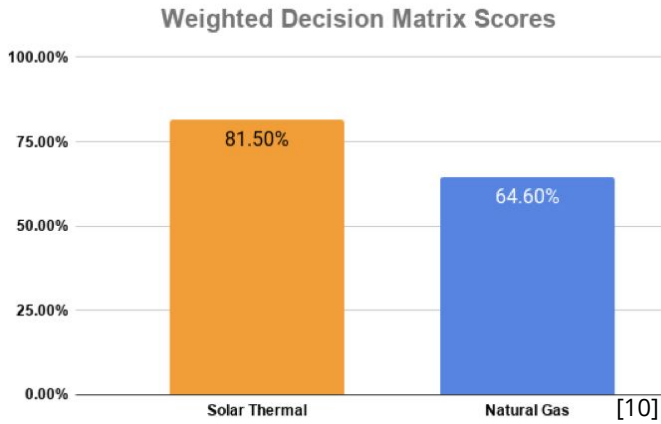
- Convert cold water into hot water for the consumer
- Transform input energy to heat energy

Functions

- Convert cold water into hot water for the consumer
- Transform input energy to heat energy

Objectives

- More Efficient
- More Environmentally Friendly
- More Economically Viable



[10]

Functions

- Convert cold water into hot water for the consumer
- Transform input energy to heat energy

Objectives

- More Efficient
- More Environmentally Friendly
- More Economically Viable

Constraints

- Safety Requirements
- Maximum CO_2 Emissions

[10]

Preliminary Consultant's Report


[9]

FOC's - Functions, Objectives, & Constraints

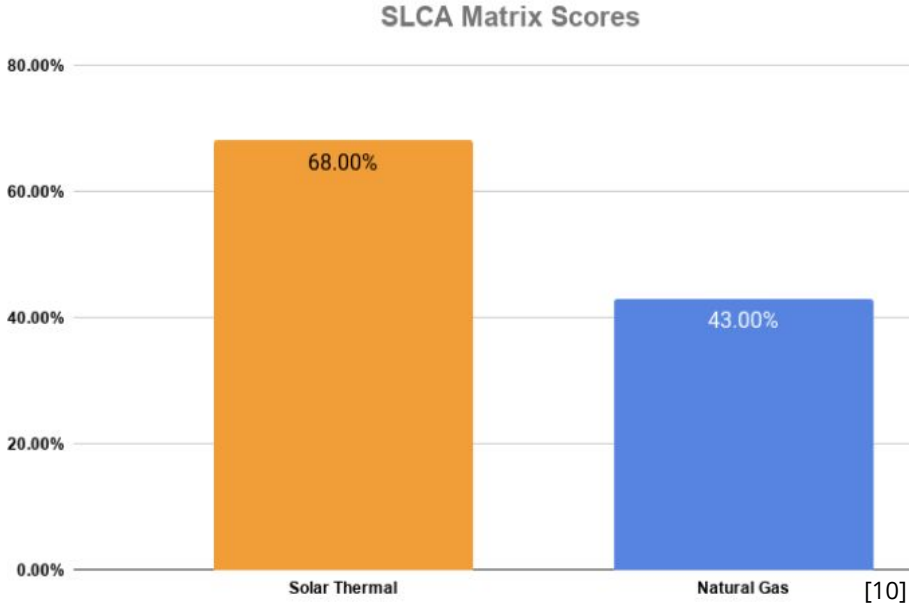
SLCA **- Streamlined Life Cycle Assessment**

Streamlined LCA

- SLCA matrix Table according to certain life stages and environmental stressors
- Solar Thermal Water Heating is preferred

. The SLCA matrix table to be filled in

SLCA Matrix	Material Choice	Energy Use	Solid Residue	Liquid Residue	Gaseous Residue
Pre-Manufacturing	(1,1) Score:	(1,2) Score:	(1,3) Score:	(1,4) Score:	(1,5) Score:
Manufacturing	(2,1) Score:	(2,2) Score:	(2,3) Score:	(2,4) Score:	(2,5) Score:
Packaging and Transport	(3,1) Score:	(3,2) Score:	(3,3) Score:	(3,4) Score:	(3,5) Score:
Use	(4,1) Score:	(4,2) Score:	(4,3) Score:	(4,4) Score:	(4,5) Score:
Disposal	(5,1) Score:	(5,2) Score:	(5,3) Score:	(5,4) Score:	(5,5) Score:
Total Score					



[10]

Final Consultant's Report


[9]

- *Economic Analysis*
- *Hybrid LCA & Impact Assessment*
- *Societal Analysis*

Final Consultant's Report


[9]

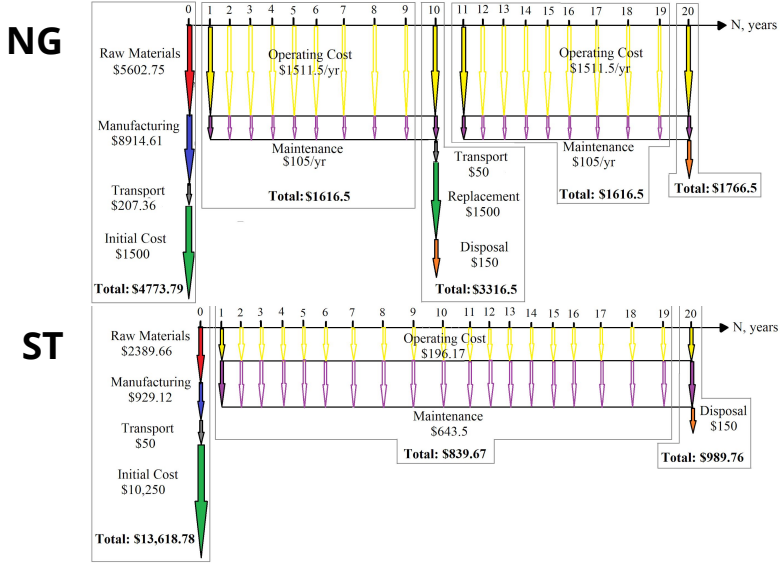
Economic Analysis

Hybrid LCA & Impact Assessment

Societal Analysis

Economic Analysis

- The cash flows relevant to each life stage was found for both alternative systems

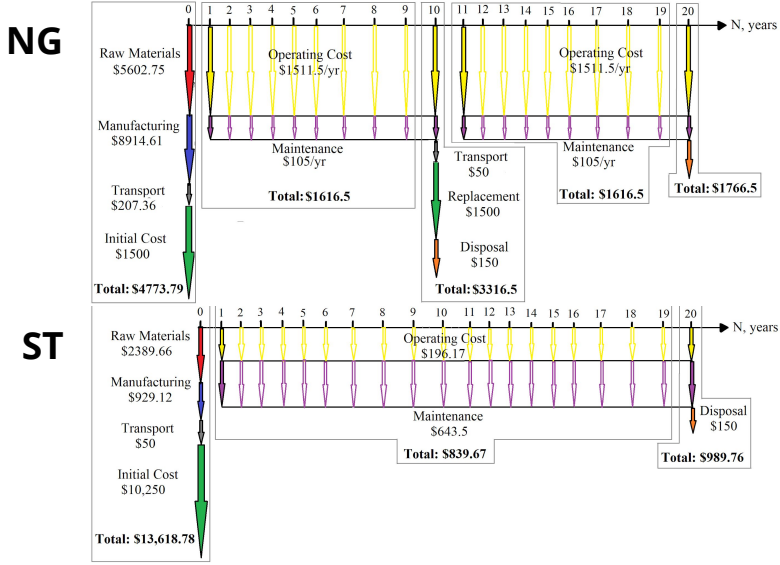


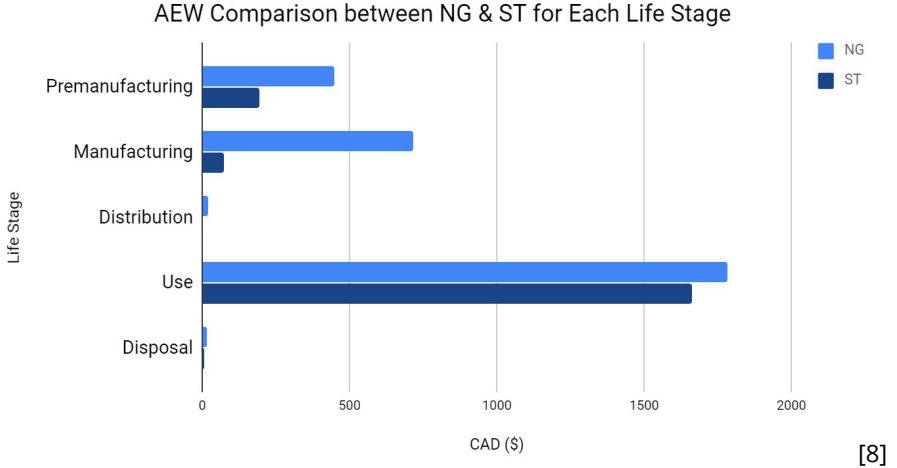
[8]

Economic Analysis

- The cash flows relevant to each life stage was found for both alternative systems

- NG has an annual equivalent cost of $2982.7
  ST $1937.01





[8]

Final Consultant's Report


[9]

- *Economic Analysis*
- ***Hybrid LCA & Impact Assessment***
- *Societal Analysis*

Hybrid LCA

- Economic Input-Output LCA
  - Pre-manufacturing
  - Manufacturing
  - Distribution
  - Use (Maintenance)
- Process-based LCA
  - Use (Performance)

Impact Assessment

- Selection
  - Global Warming
  - Acidification
  - Photochemical Smog
  - Eutrophication
  - Ozone Depletion
- Classification
- Characterization
- Valuation
  - Human Health Factor
  - Biodiversity
  - Resource Consumption

[8]

Hybrid LCA

Economic Input-Output LCA

- Pre-manufacturing
- Manufacturing
- Distribution
- Use (Maintenance)

Process-based LCA

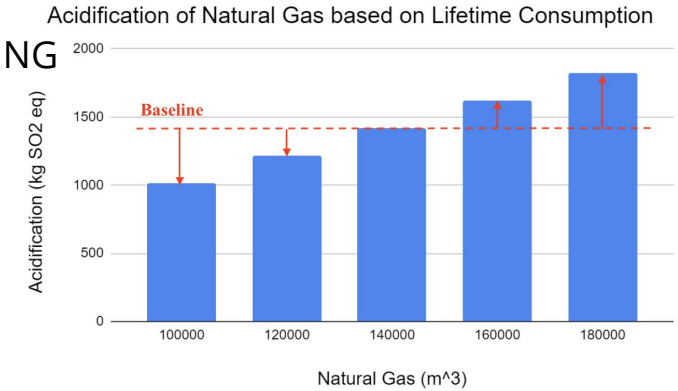
Use (Performance)

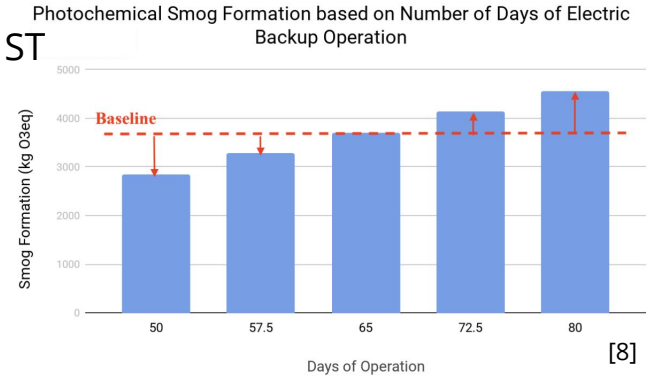
Uncertainty resulting in Sensitivity

NG

ST

Greatest variance from the baseline was 29% for NG compared to 23% for ST



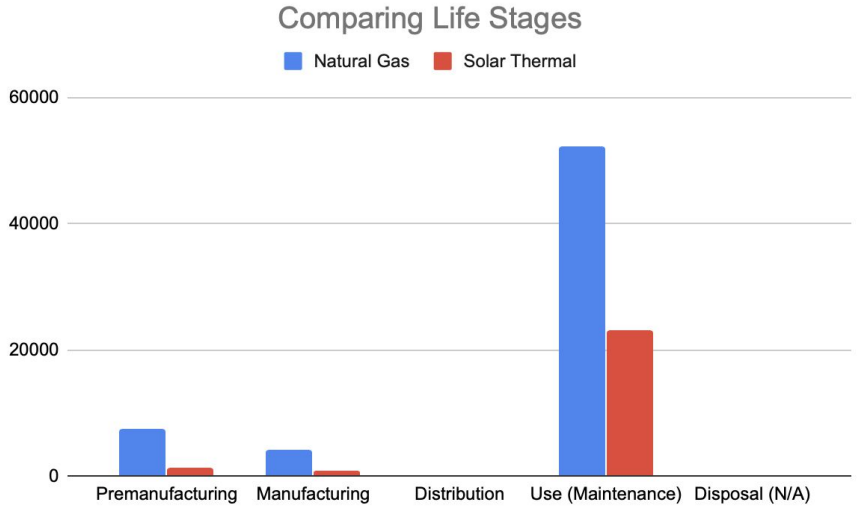


[8]

Hybrid LCA

- Total dollars per heating system for NG is $64,090.35 and for ST is $25,092.92

- ST cost more than NG across all life stages



Impact Assessment

[8]

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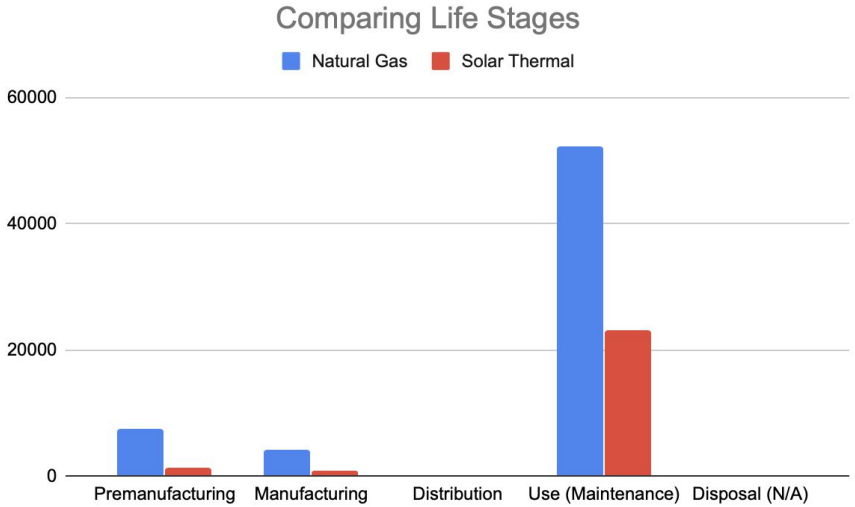
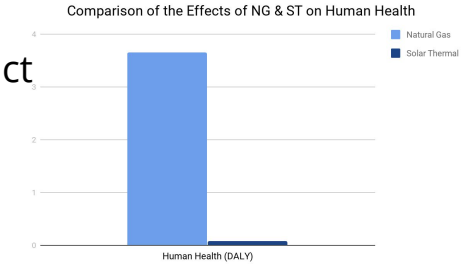
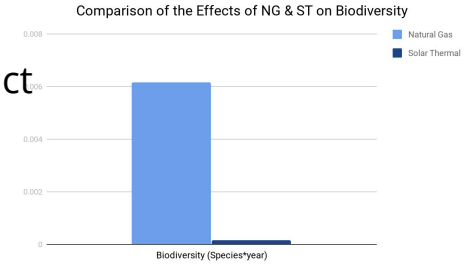


Impact Assessment

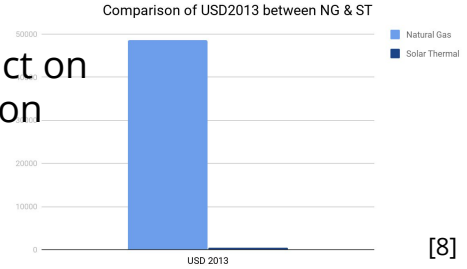
- ST had a lower impact on human health



- ST had a lower impact on biodiversity



- ST had a lower impact on resource consumption



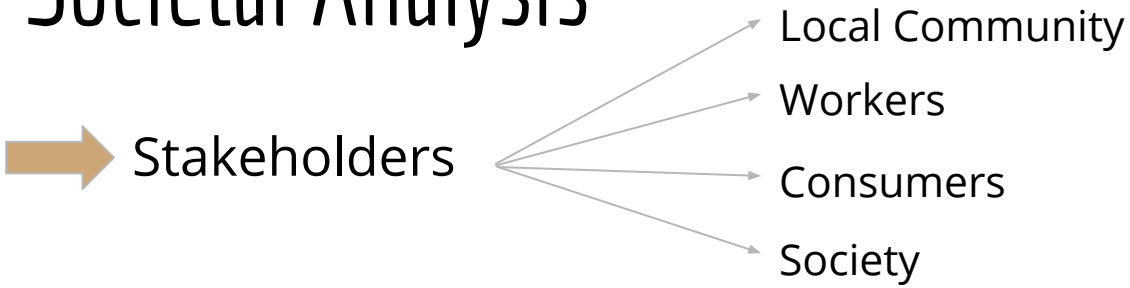
[8]

Final Consultant's Report


[9]

- *Economic Analysis*
- *Hybrid LCA & Impact Assessment*
- ***Societal Analysis***

Societal Analysis



Societal Analysis

- Stakeholders
  - Local Community
  - Workers
  - Consumers
  - Society

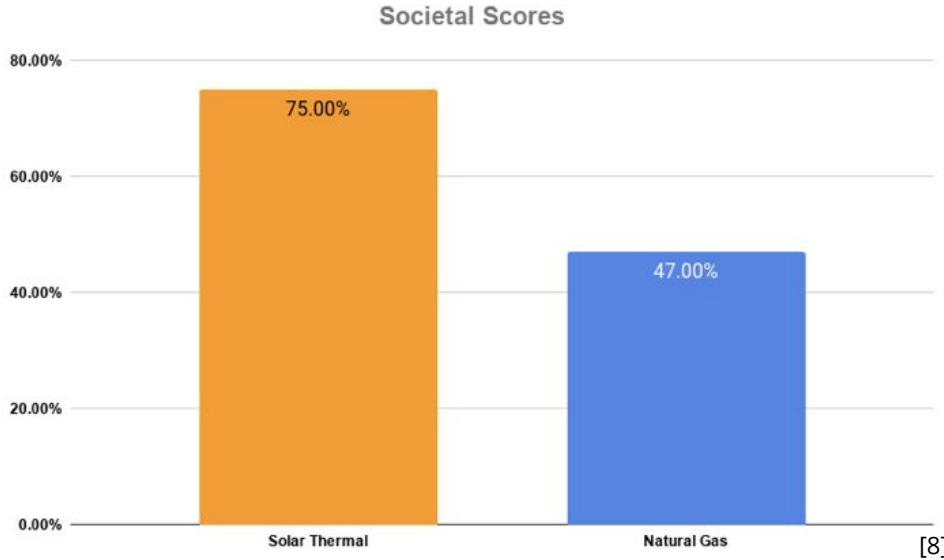
Health & Safety
Cultural Heritage
Discrimination
Working conditions
Economic Development

- How well are their needs met?
  - A score is given accordingly

Societal Analysis

- Stakeholders
  - Local Community
  - Workers
  - Consumers
  - Society
- Health & Safety
- Cultural Heritage
- Discrimination
- Working conditions
- Economic Development

- How well are their needs met?
  - A score is given accordingly
- ST had a final score of 75% which was higher than NG score, 47%.



[8]

Design for Environment Strategies


[9]

- *Minimizing Resource Consumption*
- *Use Low Impact Resources*
- *Optimize Product Lifetime*
- *Extend Material Lifetime & Design for Disassembly*

Design for Environment Strategies

[9]

- ***Minimizing Resource Consumption***
- *Use Low Impact Resources*
- *Optimize Product Lifetime*
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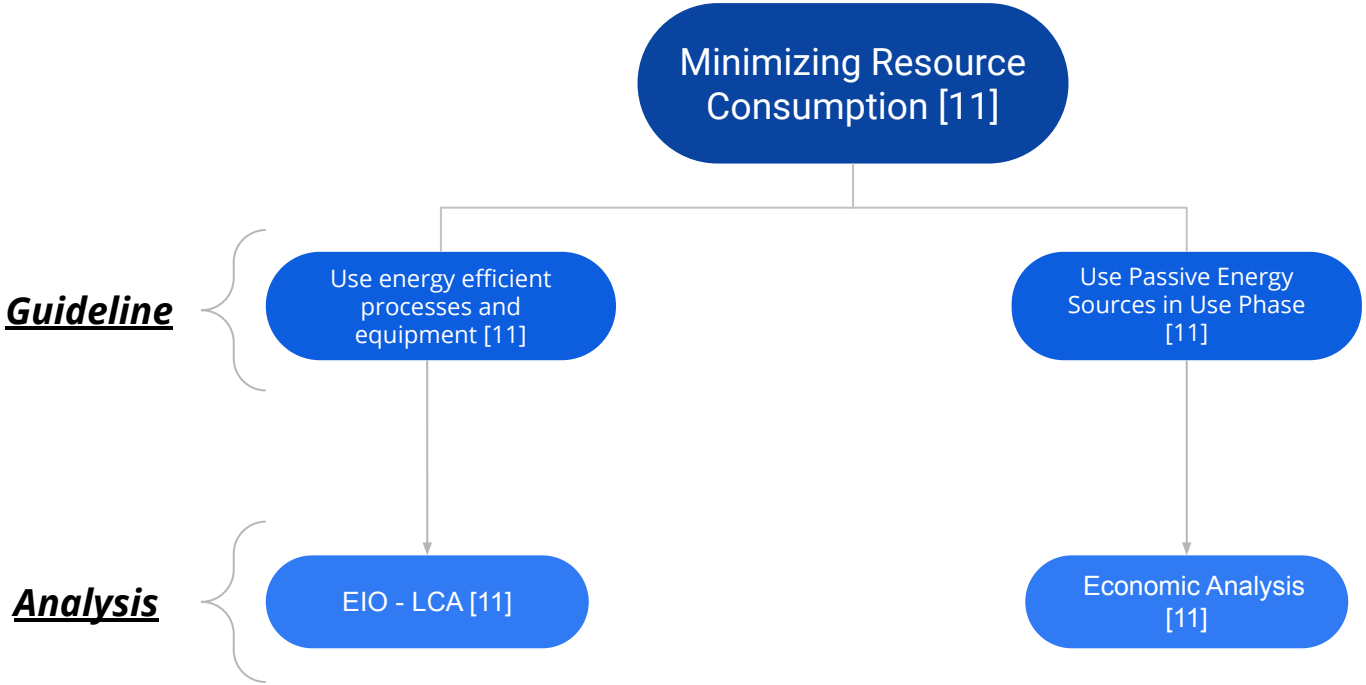
1st DfE Strategy: Minimizing Resource Consumption

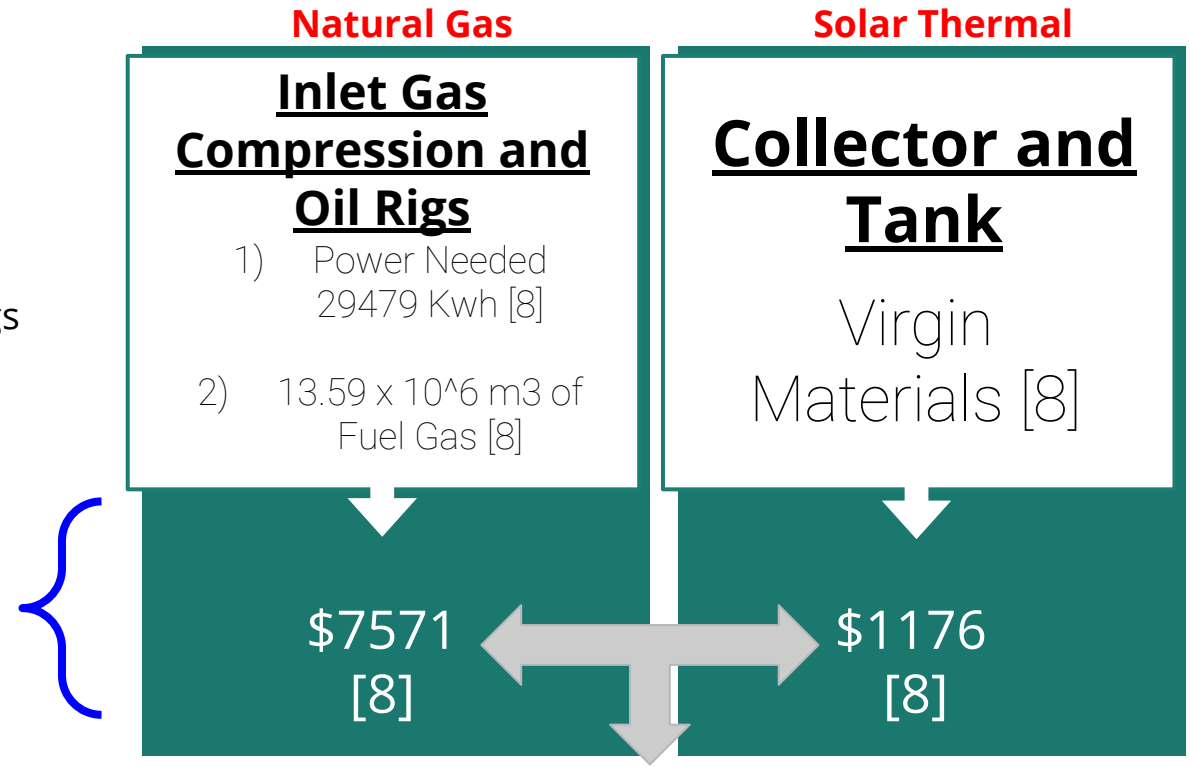


Guideline #1: Use energy efficient processes and equipment

Pre - Manufacturing Stage: Raw Materials Used

- **Natural Gas:**
  1) Energy into compressor at Wellhead [8]
  2) Fuel Gas used in the Oil Rigs [8]
- **Solar Thermal**:
  - Glass, Aluminum, and Copper found in the framework of the collector and the tank [8]

EIO - LCA

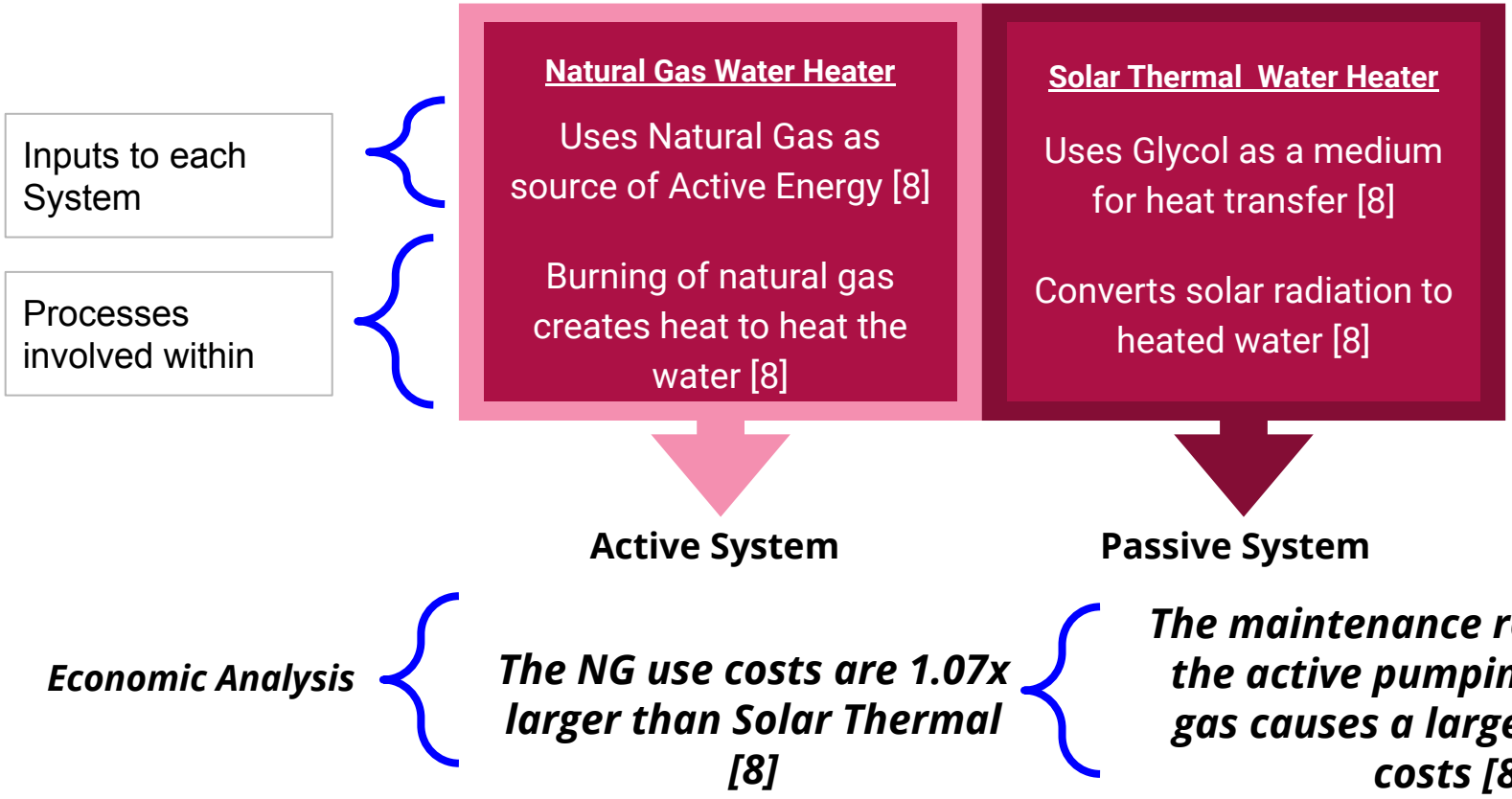


Natural Gas is a more Energy Intensive Process

Result

Pre-Manufacturing Monetary Value
Solar Thermal < **Natural Gas**

Guideline #2: Use Passive Energy Sources in Use Phase

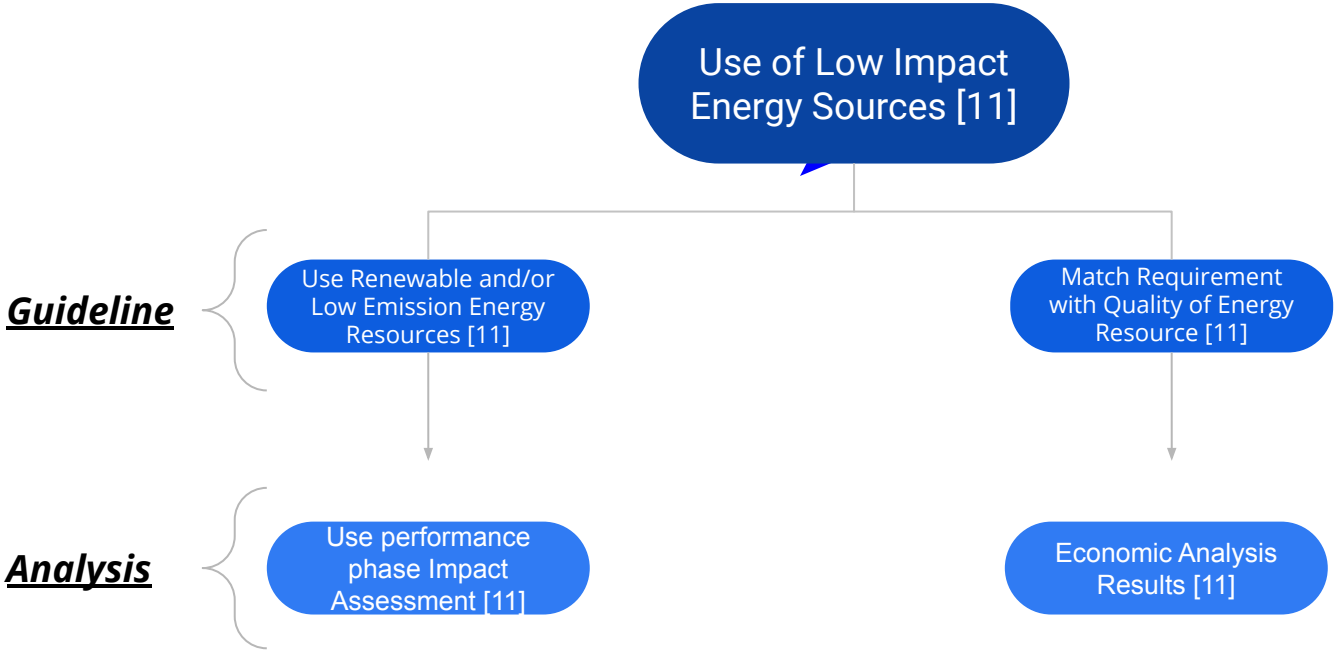


Design for Environment Strategies

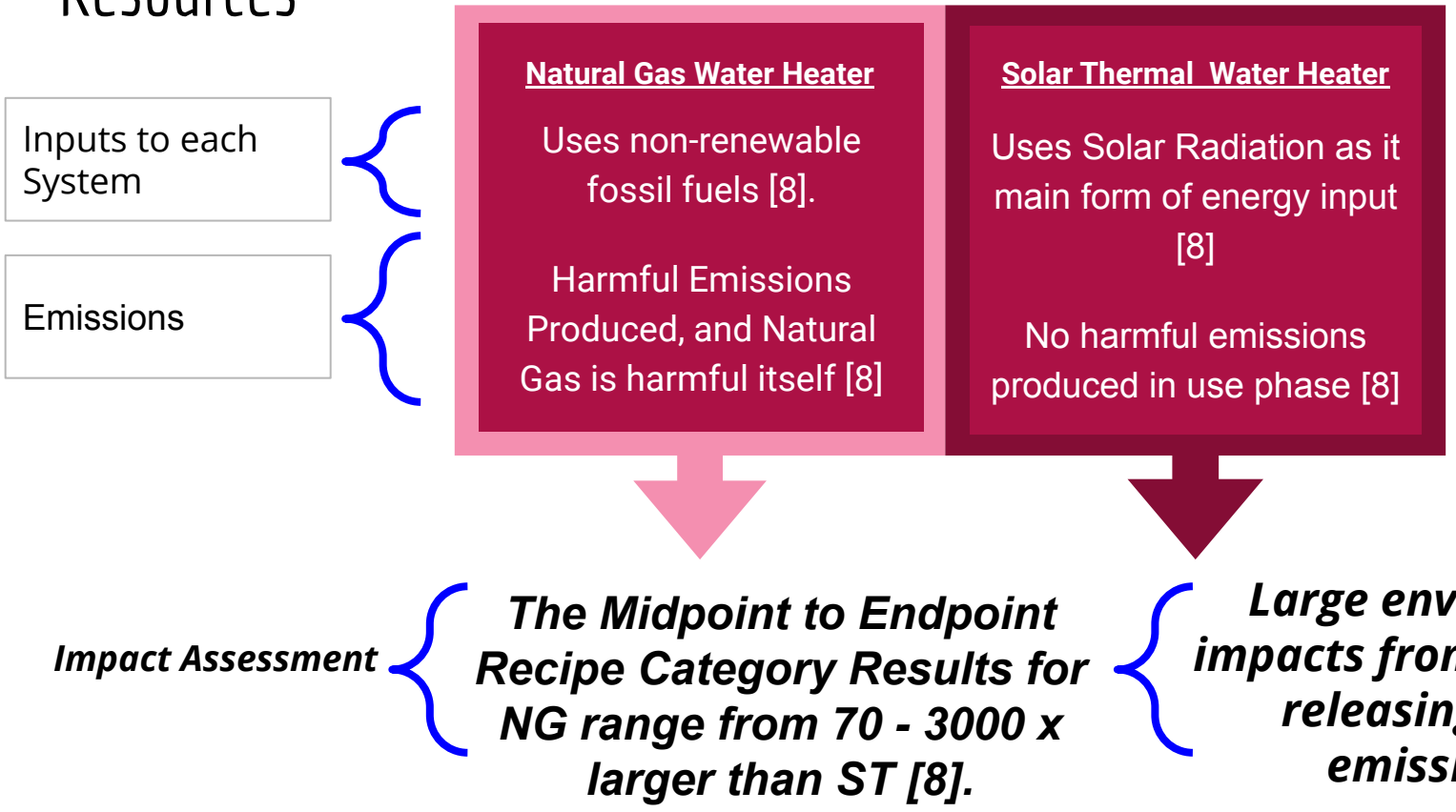
[9]

- *Minimizing Resource Consumption*
- ***Use Low Impact Resources***
- *Optimize Product Lifetime*
- *Extend Material Lifetime & Design for Disassembly*

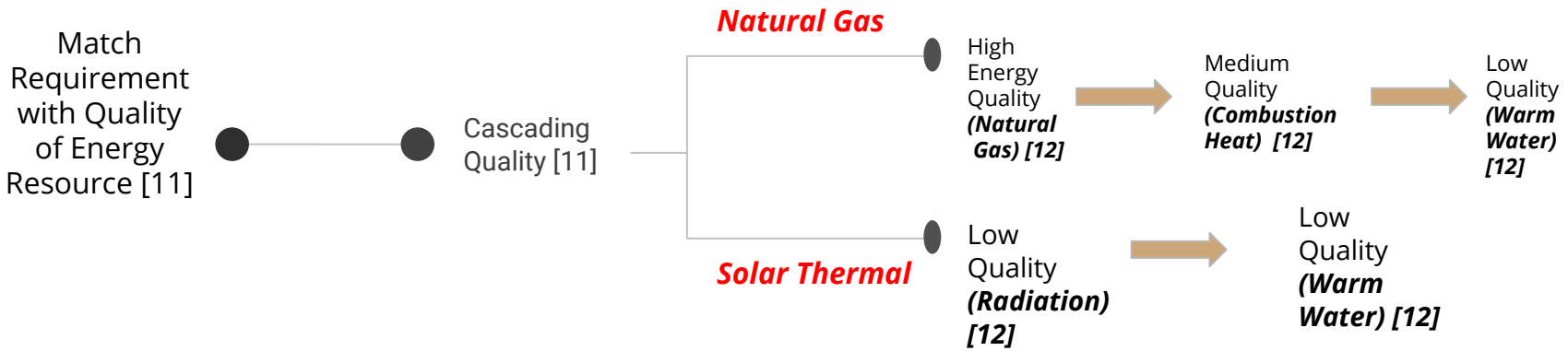
2st DfE Strategy: Use Low Impact Resources



Guideline #1: Use of Renewable and/or Low Emission Energy Resources



Guideline #2: Match Requirement with Quality of Energy Resource



Economic Analysis

AEW of Natural Gas $1782[8]

AEW of Solar Thermal is $1662 [8]

Solar More Efficient

Use Phase Results;

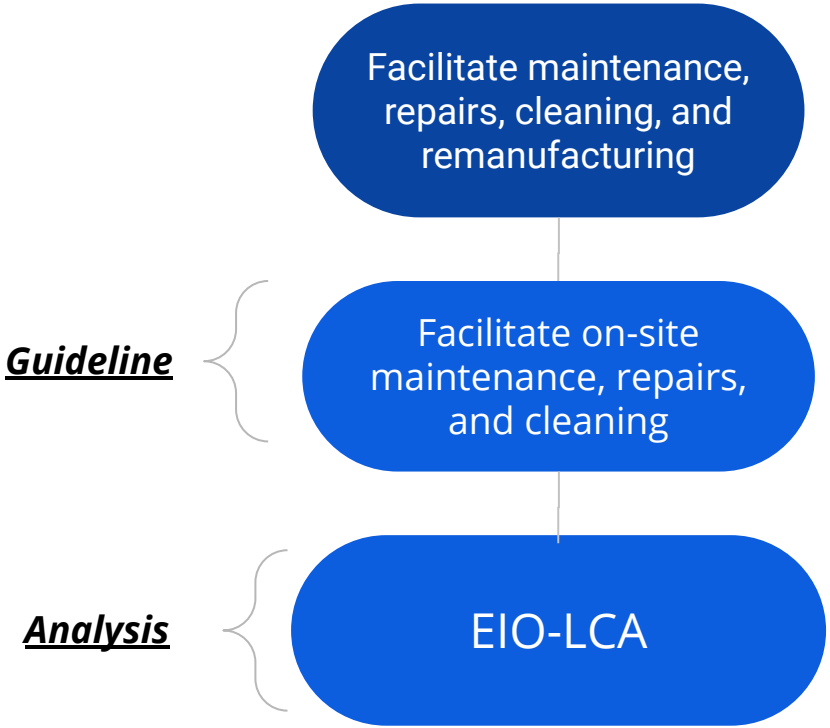
Large Amounts of Natural Gas are needed to heat the same amount of Water as compared to Solar

Design for Environment Strategies

[9]

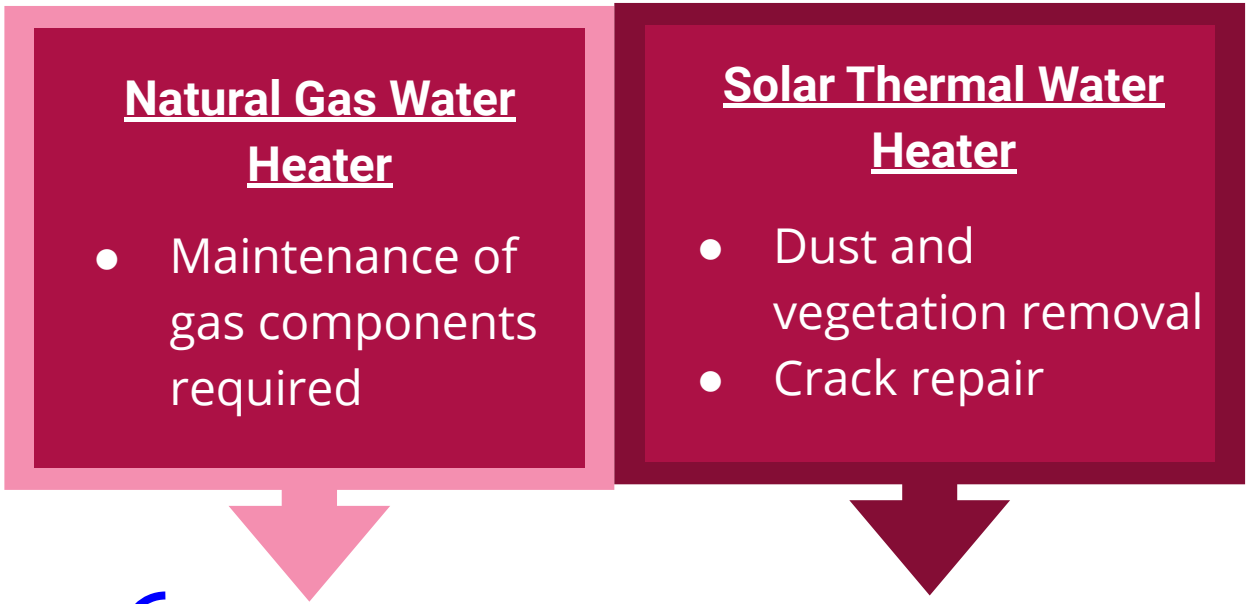
- *Minimizing Resource Consumption*
- *Use Low Impact Resources*
- ***Optimize Product Lifetime***
- *Extend Material Lifetime & Design for Disassembly*

3rd DfE Strategy: Optimize Product Lifetime



3st DfE Strategy: Optimize Product Lifetime

Note: Both systems use same tank



EIO-LCA Analysis

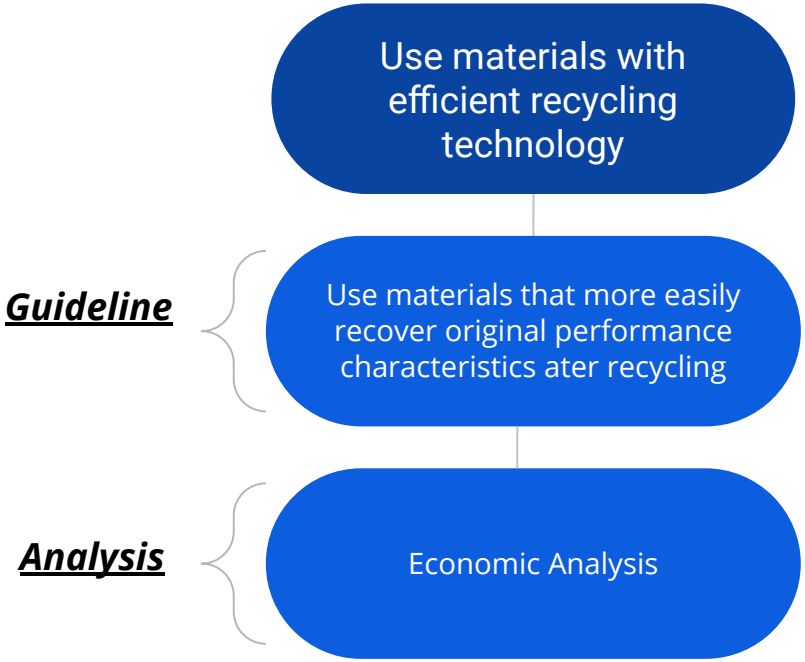
The Use Maintenance Phase of EIO-LCA shows that NG costs 2.4x more than ST [8]

Design for Environment Strategies


[9]

- *Minimizing Resource Consumption*
- *Use Low Impact Resources*
- *Optimize Product Lifetime*
- ***Extend Material Lifetime & Design for Disassembly***

4th DfE Strategy: Extend Material Lifetime



Natural Gas

- Combustion ⟶ reduce recycling ability & lifetime

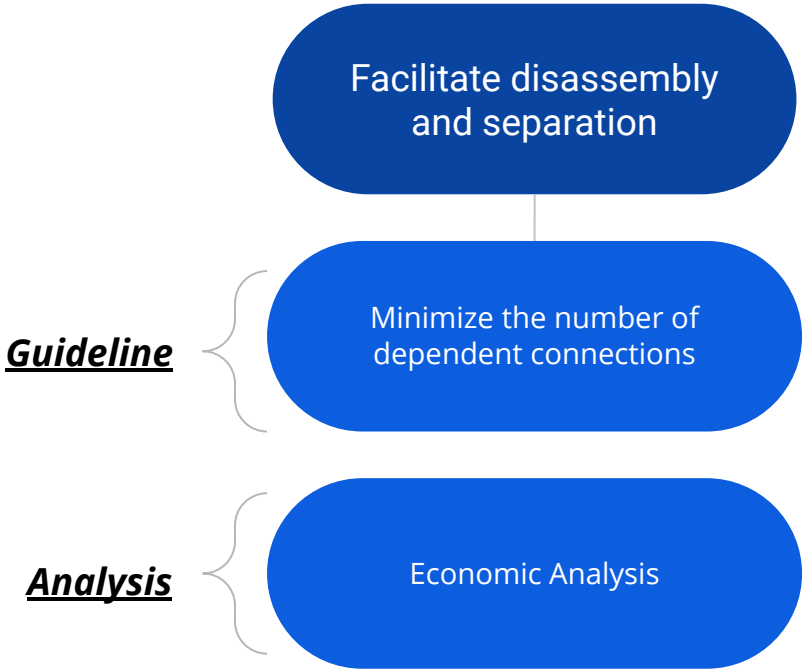
Solar Thermal

- Heat exchanger ⟶ components unaffected [13]

Over a 20 year lifetime, the replacement cost for natural gas is...

$1500 [8]

5th DfE Strategy: Design for Disassembly



Natural Gas

- 3 connections - gas supply, water supply, within house

Solar Thermal

- 3 connections - water supply, solar collectors, within house

$150 disassembly/disposal cost for both [14]

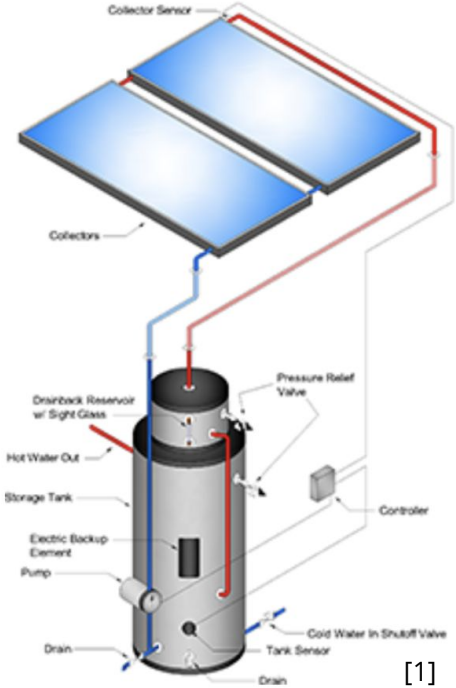
Final Recommendation

Optimal Design:

Solar Thermal water heating

Recommendations for ST (Dfe Strategies)

- **Minimize Energy Consumption:** Use more recycled materials to achieve 90-95% energy savings [8]
- **Improve Passive system:** Increase fluid thermal properties in order to increase efficiency
- **Extend Lifetime & Facilitate Maintenance:** Automated Cleaning & Tankless Alternative to Lower Maintenance Cost



[1]

Thank you!

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